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What Is a Soil Test?

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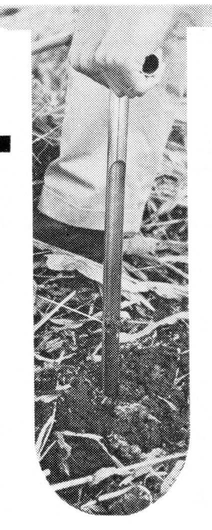
WHAT IS A SOIL TEST  ?

Soil tests can be made in several ways; some are better than others. Fully as important as the methods, however, is how well fertilizer recommendations based on soil-test results are related to actual crop responses in the field.

by J. A. Stritzel

A SOIL TEST is a chemical method for determining the nutrient-supplying power of a soil. Not all soil-testing methods are alike, nor do all fertilizer recommendations—even though based on soil tests—have the same reliability.

Reliable fertilizer recommendations are developed by *calibrating,* or correlating, laboratory soil-test values with crop responses from fertilizer-rate experiments conducted in the field for several years with a particular crop growing on a specific type of soil. If calibration has been incomplete—or perhaps even by-passed—fertilizer recommendations based on soil-test results still can be only "best guesses."

What Tests Measure . . .

Some people believe that soil tests measure the total amount of specific nutrients in the soil. This isn't true. Not all of the nutrients in the total supply are in a form readily usable by plants. So there's little relationship between the total amount of nutrients in a soil and the amount of nutrients that plants can get from that same soil.

What, then, do soil tests measure? Basically, *present soil-testing methods measure a part of the total nutrient supply that is related to what plants can take from the soil.*

A "low" soil-test value for a particular nutrient means that plants won't get enough of that nutrient to produce the highest yields possible for the prevailing soil and climatic conditions. The nutrient deficiency can be corrected by adding fertilizer containing that nutrient. The amount of the nutrient that needs to be added for a given soil-test value is determined by the fertilizer-rate experiments that have been conducted in the field, with the crop growing on a specific soil with the same soil-test value.

A Note of Caution . . .

Subtracting the numerical soil-test value obtained in a chemical laboratory from the total nutrients known to be contained in a given crop yield doesn't indicate actual fertilizer needs. Chemically extracted nutrients don't reflect the exact amount of nutrients that plant roots will take up during an entire growing season. Also, a soil sample usually represents only the surface 6 inches, while plant roots may penetrate 3-5 or more feet of soil. Hence, the difference between a numerical soil-test value and total nutrient needs is *not* a valid estimate of fertilizer needs.

Remember also that soil-test values apply only for the depth of soil sampled. The top 6 inches of two different soils, for example, may have the same test value for a given nutrient. In soil A, however, four successive 6-inch depths below the surface 6 inches may test the same as the surface 6 inches, while the corresponding 6-inch depths of soil B may have much lower test values than the surface soil. Thus, soil B has less total available nutrients in the top 30 inches than does soil A.

Field calibration compensates for the differences in the total available nutrients in two such types of soils that have the same surface test levels. The crop response to fertilizer rates in the field experiments on each soil type will indicate the appropriate fertilizer rates needed for each soil regardless of the nutrient status of the subsoil. This point emphasizes once again the importance of adequate field calibration if reliable

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fertilizer recommendations are to be made from soil tests.

Nitrogen Tests . . .

Tests for nitrogen range from a simple determination of total organic matter to a more elaborate biological test to measure the amount of plant-available nitrogen liberated by soil microbes when soils are incubated under controlled moisture and temperature conditions.

In total organic matter tests, a certain percentage of the nitrogen in the organic matter is assumed to be released for the current year's crop. So the apparent fertilizer nitrogen need is the difference between the estimated available nitrogen and the nitrogen that we assume a crop needs to produce a specified yield. Usually, the more organic matter present, the greater is the amount of nitrogen released. In practice, however, organic matter tests give a relatively crude estimate of potentially available nitrogen.

Another approach is the use of a chemical extractant to break down the easily decomposable organic matter in the soil. This easily decomposable fraction is assumed to be related to that fraction of the organic matter most easily broken down by soil bacteria. Thus, a rapid chemical test becomes an index to the amount of nitrogen in a field that may become available during the season. In practice, however, this approach hasn't correlated as closely with yield increases as is desired.

A third method uses the actual soil organisms to break down the organic matter under controlled temperature and moisture conditions. And the amount of nitrogen released during a given period is measured. This method takes more time than the chemical method but correlates better with yield increases than does the chemical test. The Iowa State University Soil Testing Laboratory uses this method for its nitrogen test.

Phosphorus Tests . . .

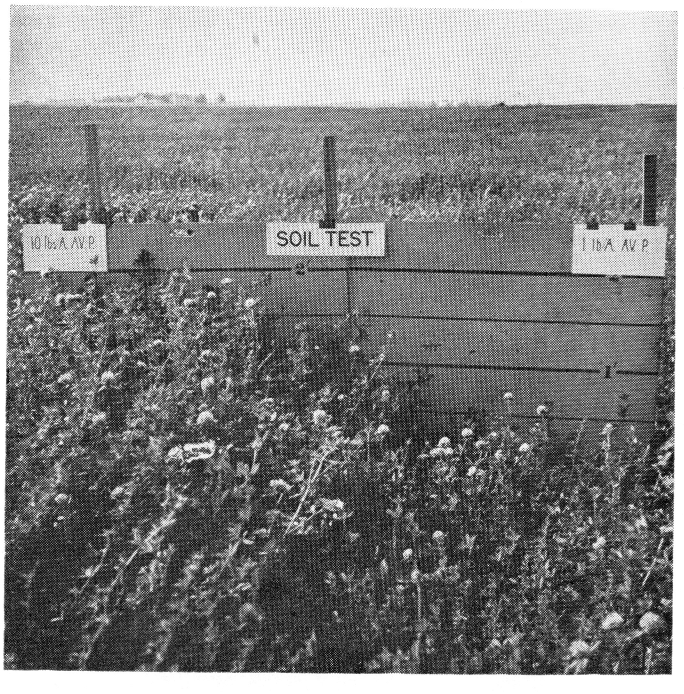
Tests for phosphorus are many and varied. These tests usually involve treating the soil with either a strong or a weak (dilute) acid or a special salt solution to extract the more soluble phosphorus fractions. The object of a phosphorus test is to extract a portion of the total soil phosphorus that is related to the amount that plants will be able to get from the soil.

Dilute acids extract less of the total phosphorus than do strong acids. In many soils, the smaller amounts of phosphorus extracted with dilute acids are more closely related to the amounts that plants can get from the soil than are the larger amounts extracted with strong acids. And the amount of phosphorus extracted with the dilute acid correlates well with the crop response to additions of fertilizer phosphorus.

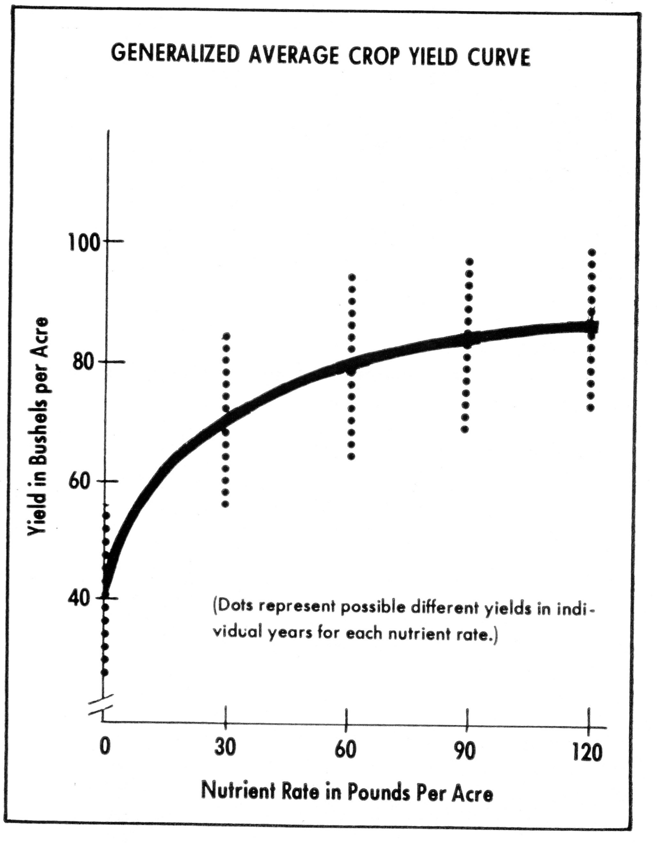
A dilute acid extractant—0.03 normal ammonium fluoride in 0.025 normal hydrochloric acid—is used in the Soil Testing Laboratory at Iowa State. Tests using this solution have been very reliable for Iowa soils.

Potassium Tests . . .

Potassium tests usually involve acid or salt solution extractants which, when reacted with the soil, replace some of the potassium held electrically by the clay particles. This electrically held po-



The legume growth above reflects the phosphorus status of the soil as indicated by soil-test values. The amount of phosphorus needed on the right to produce growth equal to that on the left has to be determined by fertilizer-rate experiments carried out in the field.



tassium is called "exchangeable" potassium. The amount of potassium on the clay that's replaced by the extracting solution is a measure of the potassium-supplying power of the soil. Iowa State uses a 1.0 normal, neutral ammonium acetate salt solution to determine available potassium in Iowa soils.

Testing for Acidity . . .

Soil acidity or alkalinity is commonly measured in terms of pH. Soils that are neither acid nor alkaline are called neutral and have a pH of 7. Acid soils have pH values below 7, and alkaline soils have pH values above 7.

Most soils in Iowa are acid, and some have pH values as low as 5. A soil with a pH of 5 is strongly acid. Increasing acidity reduces bacterial activity and the availability of some soil and applied fertilizer nutrients. It also increases the toxicity of the aluminum present in all soils. The optimum balance of the various conditions for growth of common crops appears to exist where the soil pH is about 6.5. Limestone recommendations, therefore, represent amounts that will bring the pH of acid soils to 6.5.

The pH value of soils isn't a direct measure of the amount of limestone needed to raise the pH value to 6.5. Soils high in content of organic matter and clay may require several times as much limestone as sandy soils with the same pH value but low in organic matter. Special tests in addition to measurement of soil pH, therefore, are necessary to achieve proper interpretation of pH values in terms of lime requirements.

Test Values . . .

Regardless of the testing method used for determining the available nutrients in soil, *the values obtained are of little value in themselves.* It's desirable to have the most precise and reliable values possible. But, if accurate fertilizer nutrient recommendations are to be made, the values from the soil tests *must* be calibrated against fertilizer-rate experiments in the field—for several years and under specific soil and climatic conditions.

Price Effects . . .

The chart shows a generalized crop response curve to increasing nutrient rates. Once agronomic response data, like that shown on page 7, have been obtained over a period of years for a specific crop grown on a particular soil having a given test value, an economic evaluation can be made to determine *the most profitable average fertilization rate.* This is determined by the relation of the price of the crop grown to the cost of the fertilizer nutrient concerned.

The most profitable fertilizer rate changes as the price of fertilizer or of the crop changes, as illustrated in the table. When corn is $1 or less per bushel, for instance, each dollar invested in the last 20 pounds of nitrogen (120-pound rate in this example) doesn't return a dollar's worth of additional corn. Corn must be $1.25 per bushel for this last 20-pound addition to pay its way. Maximum profit occurs when the added return in corn yield just equals the cost of the last addition of fertilizer.

Remember . . .

Some farmers believe that soil tests measure the yearly additions of fertilizer nutrients made on their soils. While soil tests can measure nutrient additions, the yearly increase in test readings usually is small unless large nutrient additions have been made.

Modest fertilizer applications in 1 year won't change the soil-test values enough to require a change in fertilizer rates for the following year. Several years are required for residual carryover of phosphorus and potassium, for example, to change soil-test values enough to warrant a change in fertilizer rates of these two nutrients. This fact, coupled with a general tendency of people to take too few cores when sampling, is the reason that we say that soil tests made at Iowa State are good for 3-5 years before retesting is necessary. Between soil tests, you can determine annual fertilizer needs by subtracting the nutrient credits for manure, legumes and carryover fertilizer from the total fertilizer needs shown in the soil-test report.

An example of the economic aspects of corn yield response to nitrogen fertilizer rates.

Nitrogen per acre	Yield increase per acre	Marginal yield increase[a]	Marginal cost[b]	Marginal return[c] Price of corn per bu.			Gross profit per acre[d] Price of corn per bu.		
				$ 1.25	$ 1.00	$ 0.75	$ 1.25	$ 1.00	$ 0.75
20 lbs.	8 bu.	8 bu.	$2.40	$ 4.17	$ 3.33	$ 2.50	$ 7.60	$ 5.60	$ 3.60
40	15	7	2.40	3.65	2.92	2.19	13.95	10.20	6.45
60	21	6	2.40	3.13	2.50	1.88	19.05	13.80	8.55
80	26	5	2.40	2.60	2.08	1.56	22.90	16.40	9.90
100	30	4	2.40	2.08	1.67	1.25	25.50	18.00	10.50
120	32	2	2.40	1.04	0.83	0.63	25.60	17.60	9.60

[a]Marginal yield increase is the additional yield increase obtained for each successive 20-pound N addition.

[b]Cost for each successive 20-pound addition of N at 12 cents/lb.

[c]Marginal return is the return per $1 invested for each successive $2.40 spent for N in this example.

[d]Phosphorus and potassium costs haven't been subtracted from the gross cost. P and K rates are constant for all N rates in this example.